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IMAGE PROCESSING

This invention relates to image processing and is of particular benefit to clustering data in binary images.

In a number of image processing applications there is a requirement to cluster objects together, i.e. objects which are related due to their close proximity to each other. For example in document image processing, text objects that are close to each other may be clustered together to form paragraphs. With binary image data this clustering can be performed by merging, i.e. removing gaps between objects that are less than a specified distance limit. The difficulty in merging binary objects into clusters is the determination of the distance limit. If the distance limit is too small then some related objects remain separate. If the distance limit is too large then gaps between clusters may be removed incorrectly.

If the separation between clusters is significantly larger than the gaps between objects within a cluster, then the setting of the distance limit is easy. In the cases where the separation between clusters is similar to the gaps between objects in a cluster, deciding the distance limit for merging is more difficult. If the separation between clusters is smaller than the gaps between objects in a cluster then it may be impossible for a single distance limit to merge objects into clusters without also incorrectly joining clusters together. In the example of text processing of document images, merging text into paragraphs is easy if the separation of the paragraphs is significantly larger than the gap between letters. However if the gap between letters is less than the separation between paragraphs (as is often the case in a document with many fonts and sizes of text), then it may

not be possible to cluster all the text into paragraphs successfully using a simple binary merging operation.

In image processing applications where the clustering of binary objects is difficult because of the close proximity of the clusters, it is often helpful to use additional information to segment the binary image. The information used to segment the binary image is generally more useful if taken from a separate source or earlier form of the image. In the example of text processing in document images, the binary image of the text objects may be segmented according to background colour, calculated from the original greyscale image of the document. Unfortunately segmentation of an image can be difficult and many techniques do not adequately account for slowly varying features or incomplete region boundaries.

We have appreciated that the process of segmenting and merging in order to cluster objects in a binary image may be made more successful and computationally efficient if they are combined into a single process, where the segmentation information is represented as the boundaries between regions. Accordingly a preferred embodiment of the invention clusters together objects in a binary image by removing the gaps between objects in the cases where the gaps are less than a specified distance limit and do not cross a region boundary.

We have observed that the merging of objects in a binary image into clusters can benefit from segmentation of that image. If the segmentation can separate clusters without dissecting them then it reduces the likelihood of incorrectly merging clusters together. This can simplify the requirements of the merging operation making it easier to successfully set a distance limit for the merging. We have also observed that the requirement of merging objects

in a binary image into clusters also simplifies the task of segmentation. As an isolated task the segmentation would need to be able to separate the whole image into distinct regions. However the merging operation has a distance limit which will keep clusters that are well separated isolated. Thus the demands on the segmentation are reduced to separating regions where the clusters would otherwise be merged together. The benefit of the invention performing both the merging and segmentation simultaneously is to take advantage of the reduced requirements of the segmentation information and the simplification in the setting of the merging distance limit.

The invention is defined with more precision in the appended claims to which reference should now be made.

A preferred embodiment of the invention will now be described in detail by way of an example with reference to the accompanying drawings in which:

Figure 1 shows schematically apparatus for identifying addresses on complex envelopes;
Figure 2 shows schematically a conventional method for applying both segmentation and merging to a binary image;
Figure 3 shows schematically an embodiment of the invention used to perform the tasks of both segmentation and merging on a binary image;
Figure 4 shows benefit of using regions boundaries for segmentation in the case of segmenting text in a document image according to background colour; and
Figure 5 shows schematically apparatus for identifying addresses on complex envelopes using an embodiment of the invention.

In an example of identifying addresses on complex envelopes in a mail processing system there is a requirement to cluster text objects into paragraphs that may be addresses. As with many other image processing applications the merging of binary text objects into paragraphs can benefit from the use of additional information to segment the image. Accordingly in the case of processing document images such as mail we have proposed in our British Patent Application No. [ ] filed on the same day as the current application, a method of clustering related text objects in an image document. The aforementioned patent uses two segmentations, one according to text colour and one according to background colour, to segment the binary image of the text objects. In the example shown Figure 1 the apparatus to identify addresses on complex envelopes, uses a simplified version that creates a segmentation from the background information only.

In Figure 1, a scanner 2 produces a 256 level greyscale image from the input document. It could of course produce other resolutions of greyscale image or indeed a colour image. This greyscale image then passes to a text object extraction unit 4 which identifies the text objects in the image and produces a binary image of these.

At the same time, the greyscale image passes to a global information segmentation unit 6 which creates a segmentation for the image based on the background greyscale level by defining regions where the grey level is the same or within a predetermined range. This could also use colour information. This segmentation data relating to background grey level is then passed to a segmentation unit 8 which also receives the binary image from the text object extraction unit 4. This then

segments the binary image of text according to the global background information supplied to it.

The output data for this is then passed to the merging unit 10 which, for each segmented region, merges text objects according to the distance between letters. Letters which are separated by less than a predetermined distance are merged together and ones which are further apart are not. This produces text blocks which are passed to a sorting unit 12. This sorts the text blocks according to those most likely to contain an address (in the case of a mail processing system) and passes these to an optical character recognition (OCR) unit 14.

Steps 8 and 10 in Figure 1 are a binary segmentation and merger. A conventional approach to both segmentation and merging of a binary image is shown in Figure 2. This requires the segmentation to separate the image into complete regions. The merging operation can then be applied to each region separately. In Figure 2 a segmentation map is created from segmentation information by a segmentation mapping unit 16. This map of segmented regions is combined with the binary image (of text or other objects) in a binary image segmentation unit 18. This outputs, in turn, separated regions of the binary image to a merging unit 20 which removes gaps between objects below a specified distance limit with each region. The output of this is then a sequence of clustered binary objects which do not cross region boundaries. The clusters are constrained by the distance limit of the merging applied. The task of using the segmentation information to separate the image into distinct regions is difficult to do accurately and therefore this system does have drawbacks.

An embodiment of the invention as shown in Figure 3 is an alternative to this. Instead of attempting to use the segmentation information to separate the image into complete regions, the task is reduced to extracting the region boundaries. Removing gaps between objects in the binary image then performs the merging operation. However, gaps are only removed if they are less than the specified distance limit and do not cross a region boundary. The result is effectively a simultaneous segmentation and merging operation with the advantage that at no point does the image have to be completely segmented. In fact, since the region boundaries do not have to be complete, the process is significantly simpler than forming an isolated segmentation.

The system of Figure 3 comprises a boundary extraction unit 22 which extracts region boundaries from segmentation information derived from the input greyscale image or some other source. This segmentation information may be information defining changes in background colour or greyscale which exceeds a predetermined limit. This gives a binary image of region boundaries which forms one of the inputs to the merging and segmentation unit 24. The other input to this is the binary image, which in the case of mail processing would come from the text object extraction unit 4 of Figure 1.

The segmentation and merging unit then merges together objects in the binary image without crossing any region boundaries. Merging is performed by removing gaps between objects that are below the merging distance limit and which do not cross a region boundary. Normally, such a process will be performed by conventional hardware programmed with software to perform this process. However, dedicated hardware circuitry could be provided to implement the segmentation and merging. The benefit of

using boundaries for segmentation is illustrated in Figure 4a)-e). Figure 4a) and b) show the original and background to a document in a mail processing system. In order to aid the clustering of text objects in the paragraphs. The background has been extracted from the original image to segment the binary text objets. This segmentation provided by the background is shown in Figure 4b. As can be seen, the background areas are obviously distinct and there is no difficulty in separating the image into complete distinct regions according to background.

Figures 4c) and d) show original and background of another envelope. The top half of the image is a table of figures and the bottom half has some text. However, the text on the lower section is printed on a background which darkens from right to left. This gradient makes it difficult to segment the image into distinct regions. On the left side, it is clear that the image has upper and lower parts which should be separated. On the right there is no apparent boundary. Complete segmentation would therefore be very difficult. However, region boundaries are simple to extract from the background and give a good accurate representation of where merging can and cannot occur. Thus, the region boundaries can be extracted from the background information and these are illustrated in Figure 4e). In this, the line dividing upper and lower parts is distinct in the left-hand portion of the image but gradually decreases in distinctness towards the right-hand edge. Using the system of Figure 3, no merging can take place across this boundary.

A further advantage of this simultaneous merging and segmentation is that, whereas normal segmentation information needs to be able to segment the whole image, in this particular system, it only needs to represent a

region boundary. This can be merely a line. It does not need to enclose the distinct region. When used with document image processing, the text objects, the background colour, text colour, text orientation, etc., can all be used to segment the whole image. However, with the current technique, incomplete boundaries such as bold lines, location of images and logos, etc., can all be used successfully to aid clustering of text objects. In addition, repetitive segmentations are normally computationally intensive. The present technique requires only a binary image of the lines not to be crossed during merging. Thus, the multiple segmentations represent a case of Or-ing a number of binary images to create a complete binary image of the region boundaries. This is computationally much less intensive.

The embodiment shown in Figure 5 shows the merging and segmentation system of Figure 3 used in the apparatus of Figure 1 and replacing the segmentation unit 8 and the merging unit 10. The segmentation information input to the boundary extraction units 22 comes from the global segmentation unit 6. The binary image input to the merging and segmentation unit comes from the text object extraction unit 4. The output of the segmentation and merging unit 24 is a set of text objects grouped into text blocks. These are then sorted for the text block most likely to be the address by the sorting unit 12 before passing to the OCR 14. The system can easily be implemented to use text colour segmentation instead of greyscale segmentation.

The invention performs the clustering of objects in a binary image where the clusters are described by a maximum distance allowed between objects and by some information that implies segmentation between clusters. The segmentation information is supplied as a binary image of

region boundary lines that are not crossed during the clustering operation. The region boundaries do not have to be complete. Since the invention is a general image processing technique for clustering of binary objects there are numerous applications. The main example used in this description has been the clustering of text objects into paragraphs in document images. Other applications could include:

- Biological Image Processing
  E.g. Clustering binary image of foreign bodies infecting cells, where the segmentation region boundaries are the cell walls.

- Geographical Image Processing
  E.g. Clustering live stock in images of fields where the region boundaries are the hedge rows.

- Image Processing in military applications
  E.g. Clustering of personnel in a building, where the binary image of personnel locations may be taken from a thermal imaging system and the segmentation region boundaries are taken as the walls in the building plans.